Comment on "Nernst effect in poor conductors and in the cuprate superconductors"

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In a recent letter, Alexandrov and Zavaritsky(AZ)[1] propose a model to explain the anomalous Nernst signal observed in the normal state of hole-doped cuprates[2, 3, 4] without invoking superconducting fluctuations. In the proposed picture[1], the thermomagnetic contributions from itinerant and localized carriers "interfere" to produce a large Nernst signal. The authors argue that this picture is relevant to the high-T$_c$ cuprates and can quantitatively describe the experimental data. The aim of this comment is to recall that one of the main assumptions of the authors regarding the experimental data is false. Contrary to what they assume, at low temperature and high magnetic fields, the magnitude of the Nernst signal, (N or e_y) easily exceeds the product of the Seebeck coefficient, S, and the Hall angle, $\tan\theta$.

Comparing the magnitude of the Nernst signal with $S\tan\theta$ is instructive to identify the origin of the anomalous Nernst signal in the normal state. The transverse voltage created by a longitudinal thermal gradient, $e_y = \frac{E_y}{\nabla_x T}$ is expressed as the difference of two terms, $\rho\alpha_{xy}$ (ρ is resistivity and α_{xy} represents the off-diagonal Peltier conductivity) and $S\tan\theta$[3]. These two terms cancel out in a simple one-band metal[3] but not in metals with different type of carriers where the two terms can add up[5]. In the scenario proposed by AZ, there is no cancelation either and the contribution of localized and itinerant carriers add up to produce a large Nernst signal. Namely, while localized carriers provide a large thermopower, only itinerant carriers contribute to the Hall conductivity, σ_{xy}. As a consequence, a significant Nernst signal is found, comparable in magnitude to $S\tan\theta$ (and $\rho\alpha_{xy}$). In their account of the experimental data, they claim that "... e_y and $S\tan\theta$ are of the same order at sufficiently low temperatures."[1]

Let us examine this statement, which is crucial for the relevance of the model since they write :"If carriers are fermions, $Stan\Theta_H$ should be larger than or of the same order of magnitude as e$_y$, because their ratio is proportional to $\sigma_{xx}/\sigma_l >> 1$ in our model."[1] Fig. 1 presents the case of $La_{1.94}Sr_{0.06}CuO_4$ which lies close to the superconductor-insulator boundary. As seen in the figure, the application of a magnetic field of 12T leads to the emergence of the well-known non-metallic resistivity of the underdoped cuprates[6]. In spite of the apparent destruction of superconductivity, a finite positive Nernst signal survives at this magnetic field in the same sample. Were it due to the presence of localized carriers, then, in the AZ picture, one would expect $e_y \sim S\tan\theta$. However, as seen in the right panel, the Nernst signal becomes almost an order of magnitude larger than $S\tan\theta$ (measured in the same magnetic field and at the same temperature). To the best of our knowledge, this observation (i.e. $e_y \gg S\tan\theta$) holds in all those cases for which both Nernst data and resistive evidence for field-induced localization are available (i.e. LSCO and Bi-2201 at sufficiently low temperature, high magnetic field and low doping level)[4]. We note also that at sufficiently large magnetic fields, the positive Nernst signal fades away while the localization does not[3]. Moreover, at lower doping levels (i.e. $x < 0.05$), LSCO displays localized behavior even in zero magnetic field but no positive e_y[3]. These observations do not seem compatible with the idea of localized excitations as the central source of the positive e_y.

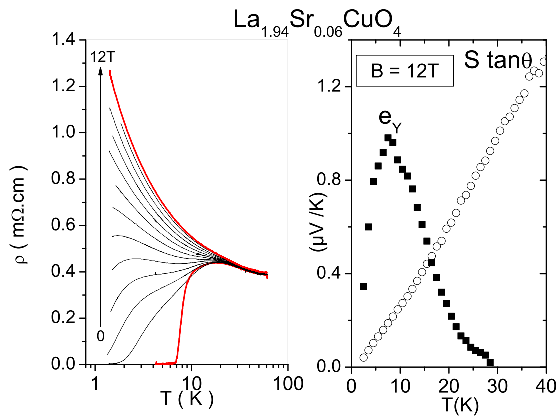

FIG. 1: Left: Emergence of a field-induced "insulating" behavior in underdoped LSCO as revealed by temperature-dependence of resistivity. Right: The Nernst signal and Stan θ at 12T as a function of temperature for the same sample.

Any proposed alternative to the superconducting fluctuations[2, 3, 4] as the origin of the anomalous Nernst signal is expected to explain these features. The proposed model[1] does not meet this requirement to qualify as a relevant explanation of the anomalous Nernst signal in cuprates.

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[1] A. S. Alexandrov and V. N. Zavaritsky, Phys. Rev. Lett. **93**, 217002 (2004).
[2] Z. A. Xu *et al.*, Nature (London) **406**, 486 (2000).

[3] Y. Wang *et al.*, Phys. Rev. B **64**, 224519 (2001); Phys. Rev. Lett. **88**, 257003 (2002); Science **299**, 86 (2003).

[4] C. Capan *et al.*, Phys. Rev. Lett. **88**, 056601 (2002); Phys. Rev. B **67**, 100507(R) (2003).

[5] R. Bel, K. Behnia, and H. Berger, Phys. Rev. Lett. 91, 066602 (2003).

[6] Y. Ando et al., Phys. Rev. Lett. 75, 4662 (1995).